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RESEARCH DEPARTMENT

Pulse sound:

protection ratios for 625-line colour transmissions in a 5 MHz channel: specification of transmitter and receiver response/frequency characteristics

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THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

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PULSE SOUND : PROTECTION RATIOS FOR 625-LINE COLOUR TRANSMISSIONS IN A 5 MHz CHANNEL : SPECIFICATION OF TRANSMITTER AND RECEIVER RESPONSE/FREQUENCY CHARACTERISTICS

SUMMARY

In this report the response/frequency characteristics of transmitters and receivers for a 625-line NTSC colour television system with pulse sound occupying a 5 MHz channel are discussed and the protection ratios for co-channel and adjacent-channel interference are deduced.

1. INTRODUCTION

A method of transmitting the sound content of a television programme has been proposed[1] in which the sound signal is conveyed by positionally-modulated pulses inserted in the line-blanking period of the video waveform. The method enables the whole of the available transmission channel bandwidth to be used for a composite vision and sound signal and, as a result, it is possible to accommodate a 625-line television transmission in the existing 5 MHz channels of the v.h.f. bands without serious loss of resolution.[2] The method therefore offers a possible solution to the problem of replacing the existing 405-line v.h.f. transmissions by 625-line transmissions without the need for a period during which the v.h.f. programmes are duplicated on 625 lines in the u.h.f. bands.

In this report, the system parameters are considered, assuming that the existing network of Bands I and III transmitters would be used to radiate 625-line, NTSC colour television signals with a colour subcarrier frequency of approximately 3·6 MHz, and pulse sound.

Ideally, the degree of interference between co-channel and adjacent-channel transmissions ought to be the same, or at least no worse, than that which would occur if the existing 405-line transmissions were modified to include chrominance signals with a 2·66 MHz subcarrier. The protection ratios for 625-line, NTSC colour transmissions with pulse sound are therefore compared with the corresponding figures for 405-line, NTSC colour transmissions with a.m. sound, and the required transmitter and receiver response/frequency characteristics for the former system are determined.

2. CO-CHANNEL INTERFERENCE

2.1. 405-Line Colour Transmissions with A.M. Sound

The internationally accepted co-channel protection ratios for a 405-line monochrome system are:

45 dB for vision carriers separated by less than 1,000 Hz but not synchronised.[3]

35 dB for vision carriers separated by a multiple of the line frequency plus or minus one-third of the line frequency,[4] with 1,000 Hz tolerance.

A study of available evidence[5] regarding the effect of sinusoidal interference leads to the conclusion that the protection ratios for a 405-line colour system using a colour-subcarrier frequency of approximately 2·66 MHz would be substantially the same as those for the corresponding monochrome system. This is because the subjective effect of interference between the wanted and unwanted colour subcarriers would, with typical pictures, be less visible than the luminance beat-pattern due to interference between the vision carriers.

2.2. 625-Line Colour Transmissions with Pulse Sound

The internationally accepted co-channel protection ratios for a 625-line monochrome system are:*

* The protection ratios given apply to the conventional system employing f.m. sound.

45 dB for vision carriers separated by less than 1,000 Hz but not synchronised.[3]

30 dB for vision carriers separated by a multiple of the line frequency plus or minus one-third of the line frequency,[4] with 1,000 Hz tolerance.

For the reason given in Section 2.1, these protection ratios are considered to apply to the corresponding colour system, using a colour subcarrier frequency of approximately 3·6 MHz.

Preliminary tests have been made which indicate that there is no significant change in the visibility of co-channel interference when line-frequency pulses are used to convey the sound signal. The protection ratios given above for a 625-line system with f.m. sound would therefore apply to a 625-line colour system with pulse sound.

It therefore follows that, if the 405-line transmitter network were modified so as to radiate 625-line, NTSC colour transmissions with pulse sound in the existing 5 MHz channels, co-channel interference would remain unchanged for non-offset transmissions and would tend to be reduced for offset transmissions on account of the 5 dB greater advantage derived from offset working with the 625-line standard.

3. ADJACENT-CHANNEL INTERFERENCE

The spectra of interfering 405-line colour transmissions with a.m. sound and 625-line colour transmissions with pulse sound are shown in Figs. 1(*a*) and 1(*b*) respectively; in each case, the effects of vestigial-sideband attenuation at the transmitter have been ignored and the spectrum of the wanted transmission has been omitted from the diagram. It can be seen that the 625-line system would be inherently more subject to lower-adjacent channel interference than the existing 405-line system. In order to minimise this interference, it would be necessary to attenuate the upper sideband at each transmitter so as to:

(a) Suppress the image of the colour subcarrier.

(b) Suppress vision sidebands in the neighbourhood of the colour subcarrier of the upper-adjacent channel.

It seems improbable that the suppression at present provided at v.h.f. transmitting stations would be adequate. Fig. 2 shows a characteristic typical of present-day practice together with a proposed improved characteristic for colour transmissions with pulse sound which would result in a substantial improvement in the lower-adjacent-channel protection ratio; the characteristic approximating to the proposal which was used for laboratory measurements of adjacent-channel interference is also shown in Fig. 2.

3.1. 405-Line Colour Transmissions with A.M. Sound

The monochrome protection ratios for "just tolerable" interference are:

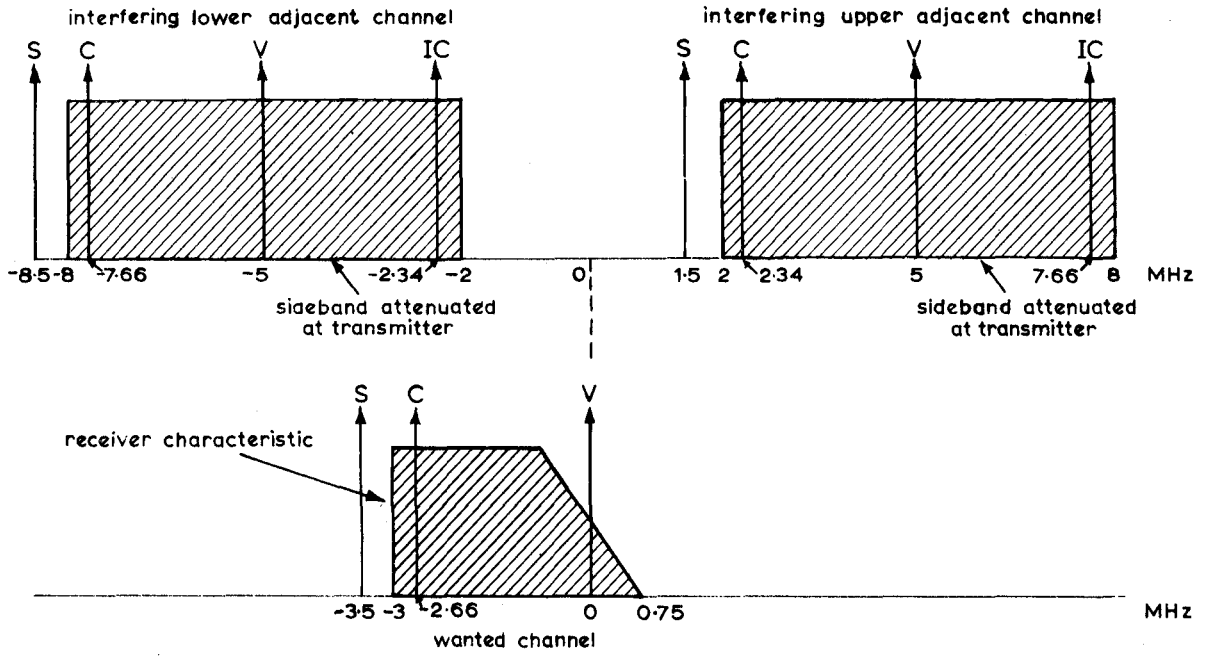
Upper adjacent channel : -2 dB.[6]

Lower adjacent channel: -12 dB.[7]

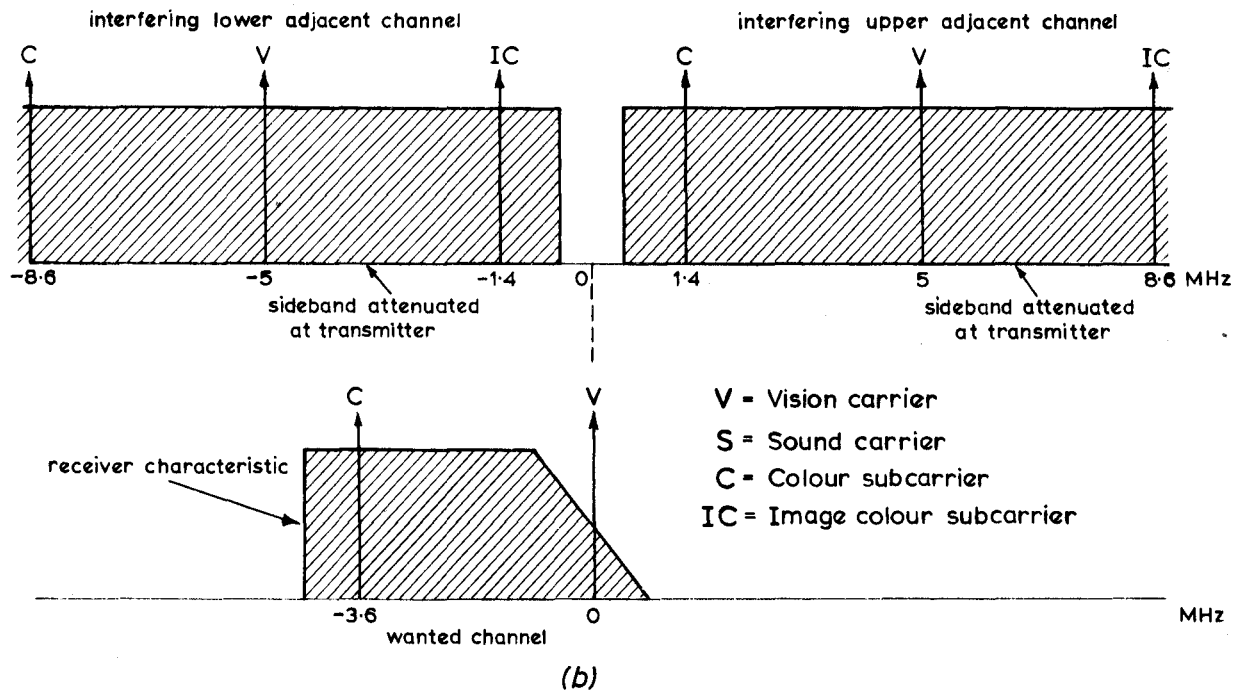
Fig. 1(*a*) shows that the colour subcarrier of the upper-adjacent channel has a frequency spaced 2·34 MHz from the wanted vision carrier. In a monochrome or colour receiver designed for reception of a 405-line colour transmission a trap would be provided to attenuate this colour subcarrier, and it seems reasonable to assume that the attenuation of this trap would be similar to that of the upper-adjacent sound trap provided in existing 405-line monochrome receivers. The 2·34 MHz beat resulting from the interfering colour subcarrier would appear within the chrominance band of the wanted transmission and would consequently require 10 dB[5] more protection than the 1·5 MHz component resulting from the interfering sound carrier. Since the colour subcarrier level will not exceed -8 dB with respect to the sound carrier level, however, the net increase required in the protection ratio is 2 dB. The two interfering signals are therefore of comparable importance and it is reasonable to assume that the combined subjective effect is proportional to the total power of the two interfering beats. On this basis, the required protection ratio for the upper-adjacent channel is + 2 dB.

It must be remembered that if a colour service on the 405-line standard were implemented, many viewers would use existing types of monochrome receivers for a considerable period. These receivers are not equipped with a trap to attenuate the colour subcarrier of the upper-adjacent channel and would consequently be more susceptible to interference arising from the 2·34 MHz beat frequency. The protection ratio for an interfering sinusoidal wave at this frequency is 40 dB[5] and since the colour subcarrier is at least 14 dB below the vision carrier, this will be reduced to 26 dB. From an examination of the characteristics of current receivers, it seems unlikely that the response to the interfering colour subcarrier would exceed -20 dB.* The estimated protection ratio for the upper-adjacent-channel colour transmission is therefore +6 dB which is 8 dB greater than that required for a monochrome transmission.

* All receiver attenuations are given relative to the maximum response.



(a)



(b)

Fig. 1 - Spectra of interfering v.h.f. transmissions, ignoring effects of v.s.b. filters at transmitters (wanted transmission omitted)

(a) V.H.F. 405-line colour system with a.m. sound
(b) V.H.F. 625-line colour system with pulse sound (video and vestige bandwidths not specified)

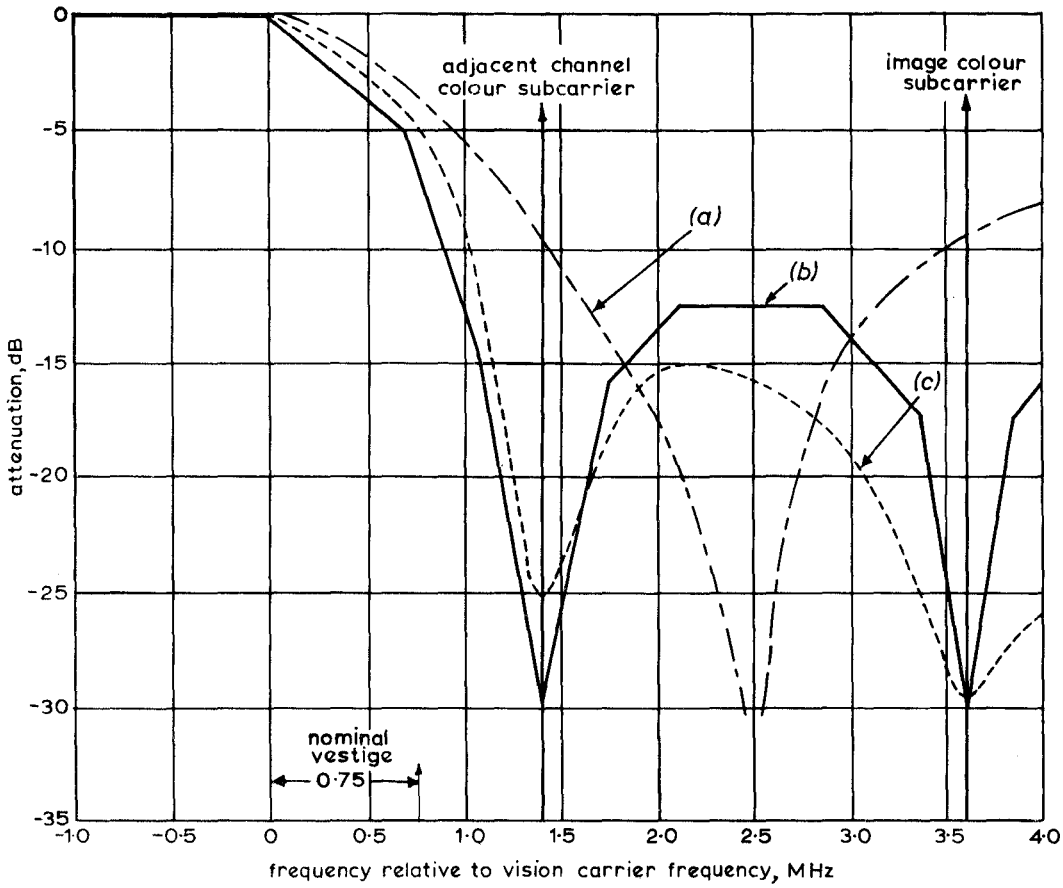


Fig. 2 - Attenuation of upper sideband at v.h.f. transmitter

(a) Attenuation of typical 405-line transmission
(b) Proposed characteristic for 625-line, pulse-sound transmissions
(c) Characteristic used for adjacent-channel interference measurements

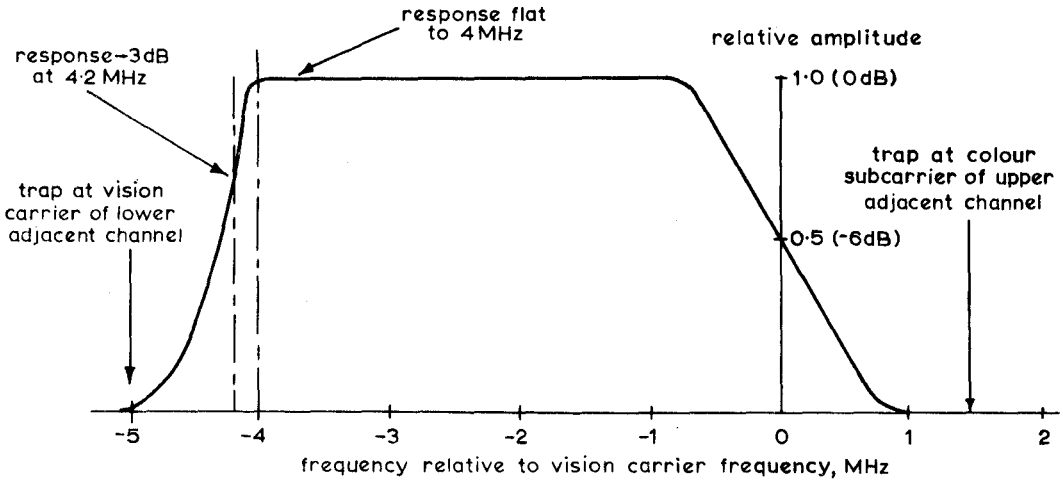


Fig. 3 - Proposed receiver characteristic for 625-line colour transmissions with pulse sound

Note: Response figures are relative to the maximum response

Fig. 1(*a*) shows that the image of the colour subcarrier of the lower-adjacent-channel is spaced 0·32 MHz from the wanted colour subcarrier. The protection ratio for an interfering sinusoidal term at this frequency is 40 dB[5] and since the colour subcarrier is at least 14 dB below the vision carrier, this figure will be reduced to 26 dB. To maintain the monochrome protection ratio of -12 dB, therefore, the attenuation in the transmitter at the image colour subcarrier frequency would need to be 38 dB. There is some doubt, however, that a protection ratio of -12 dB could be achieved since it might be difficult to suppress the sidebands of the image colour-subcarrier sufficiently at the transmitter. Bearing this in mind, it is thought that a protection ratio of -6 dB would probably be achieved. Summarising, therefore, the protection ratios for a 405-line colour system with a.m. sound would be:

Upper adjacent channel : +2 dB (+6 dB for existing types of 405-line receivers).

Lower adjacent channel : -6 dB.

3.2. 625-Line Colour Transmissions with Pulse Sound

3.2.1. Upper Adjacent Channel

Fig. 1(*b*) shows that the vision carrier and colour subcarrier of the upper-adjacent channel would beat with the wanted vision carrier to produce beat patterns of 5 MHz and 1·4 MHz respectively. Interference due to the 5 MHz beat is unlikely to be significant and interference due to the upper-adjacent-channel colour subcarrier, which would impair the luminance component of the wanted picture, would be reduced by use of the minimum acceptable vestige bandwidth. (See Section 3.2.2.)

3.2.2. Lower Adjacent Channel

Fig. 1(*b*) shows that the vision carrier signal of the lower adjacent channel would beat with the wanted vision carrier to give a 5 MHz interference pattern and with the wanted colour subcarrier to give a beat pattern of 1·4 MHz; the latter effect is the more serious.

The sidebands of the vision carrier of the lower adjacent channel would cause interference in two ways:

(i) The luminance component of the wanted picture would be impaired.

(ii) The sidebands would beat with the wanted chrominance subcarrier causing coloured interference patterns.

Use of the minimum acceptable vision-signal bandwidth and vestige bandwidth would reduce the interference. The minimum acceptable bandwidths are thought to be 4·2 MHz and 0·75 MHz for the video signal and vestige respectively. These figures are assumed in the proposed receiver characteristic shown in Fig. 3 and in the proposed transmitter specification shown in Fig. 2.

4. MEASUREMENTS OF ADJACENT-CHANNEL INTERFERENCE

An Ultra "Bermuda" receiver and an American R.C.A. colour receiver (CTC 16) were slightly modified and lined up to approximate to the preferred characteristic shown in Fig. 3. The characteristics of the modified receivers, including the attenuations achieved by the "trap" circuits, are shown in Fig. 4. Adjacent-channel measurements

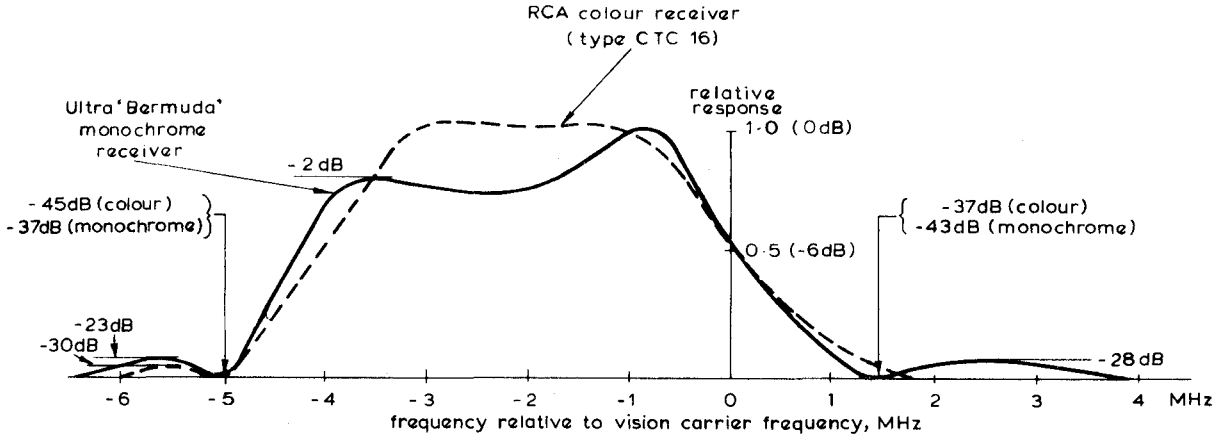


Fig. 4 - Characteristics of Ultra "Bermuda" monochrome receiver and R.C.A. Type CTC 16 colour receiver used for tests

were made using NTSC colour transmissions and the transmitter filter shown dotted in Fig. 2. Colour bars were used as the wanted picture in a number of the tests. The interference was adjusted to be "just perceptible" and 10 dB was subtracted from the corresponding ratio of wanted to unwanted signal in order to give the protection ratio; the figure of 10 dB was derived from a preliminary test and is confirmed by previous work.[5]

If the NTSC colour system were adopted, the colour subcarrier of each transmission would have a frequency, relative to the vision carrier, of an odd multiple of half the line-scanning frequency. Thus, if the vision-carrier frequencies of adjacent-channel 625-line transmissions were arranged to have "whole-line" offset, each beat between a vision carrier and a colour subcarrier would have half-line offset and low visibility. To assess the advantages of this type of frequency allocation, measurements were carried out with adjacent-channel vision-carrier frequencies with "whole-line" offset and with "half-line" offset. The latter case results in the worst interference and corresponds to the condition assumed in the estimates of protection ratios given in Section 3.

5. ADJACENT-CHANNEL PROTECTION RATIOS

The recommended protection ratios for the 405-line colour and compatible monochrome systems derived in Section 3 are summarised in Table 1. Recommended protection ratios for a 625-line colour system, with pulse sound, are summarised in Table 2. These figures are derived from measurements of protection ratios made using the modified receivers and described in Section 4.

Tables 1 and 2 apply when there is no special control of the frequency difference between the wanted and unwanted vision carriers.

TABLE 1

405 Lines - A.M. Sound

INTERFERENCE	COLOUR PROTECTION RATIO dB
Upper adjacent channel	+2*
Lower adjacent channel	-6

* +6 dB for existing types of 405-line, a.m. sound receiver.

TABLE 2

625 Lines with Pulse-Sound

INTERFERENCE	COLOUR PROTECTION RATIO dB
Upper adjacent channel	-1
Lower adjacent channel	+8

Whole-line offset was found to change the protection ratio for upper-adjacent-channel interference by a negligible amount. On the other hand, the protection ratio for lower-adjacent-channel interference was improved from +8 to -5 dB. It may at first sight seem surprising that no improvement in upper-adjacent-channel protection was obtained. This is thought to be because the interfering picture was chosen to contain a large amount of high-frequency energy. Finally it should be noted that the colour protection ratios of Tables 1 and 2 will also apply to the case of compatible monochrome reception. The measurements using the colour and monochrome receivers described in Section 4 confirmed that the impairment of the colour and compatible monochrome pictures was similar.

6. CONCLUSIONS AND RECOMMENDATIONS

The appraisal made in this report leads to the following conclusions regarding the parameters and performance of a 625-line NTSC colour system (subcarrier frequency $\simeq$ 3·6 MHz) with pulse sound, operating in the existing 5 MHz channels of Bands I and III:

(a) The nominal vestige bandwidth should be 0·75 MHz.

(b) The nominal video bandwidth should be 4·2 MHz.

(c) The unwanted upper sideband would need to be attenuated at the transmitter approximately as indicated in Fig. 2(*b*) or 2(*c*).

(d) The receiver response/frequency characteristic should approximate to that shown in Fig. 3.

(e) The protection ratio against co-channel interference would remain unchanged for non-offset colour transmissions and would be improved by about 5 dB for nominally offset colour transmissions compared with those for the existing 405-line system.

(f) The protection ratio against upper-adjacent-channel interference would be better than that required by the 405-line system as modified for colour.

(g) The protection ratio against lower-adjacent-channel interference could be worse by some 14 dB than that for a 405-line system modified for colour.

(h) The operation of adjacent channels with "whole-line" offset would make no difference to the protection against upper-adjacent-channel interference ((f) above) but would result in an improvement of 13 dB in the case of lower-adjacent-channel interference ((g) above).

If the transmissions were confined to monochrome, the conclusions would be much the same, except that the required protection ratios would be at least as good as those indicated for colour transmissions with whole-line offset of vision carriers.

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